ARE YOUR MUSHROOMS SAFE TO EAT?

Raw commercial mushrooms, obtained from the supplier of local food stores, have been tested in a bioassay (Toth and Erickson, 1986) similar to those used for synthetic organic chemicals. We can therefore perform a risk assessment on raw mushrooms similar in all respects to the risk assessments performed on synthetic organic chemicals. In the mushroom experiment, there was one control group of 50 mice for each sex and one experimental group of 50 mice for each sex, the former kept on a normal diet and the latter fed the material under test at an average rate of about 157,000 mg/kg-day for their lifetime (assuming mice weigh 30 g). Feeding of the dosed group was *ad lib* mushrooms (without other feed) 3 days/week, normal diet 4 days/week; while the control group received the normal diet. Average mushroom consumption was 11 g/day/mouse during days on which mushrooms were the only food available (mushrooms are about 90% water).

The experiment was continued for the natural lifetime of the animals, and no differences were seen in the lifetime of the dosed animals versus the control groups. However, the average weight of the dosed animals was substantially lower than the average weight of the control groups. There were increased incidences of tumors in several organs:

Tumor site:type	Sex	Control Group	Dosed Group	Significance
Bone:various	F	0/50	8/50	0.003
Bone:various	M	0/50	8/50	0.003
Forestomach:various	F	0/50	19/50	2.3×10^{-7}
Forestomach:various	M	2/50	14/50	0.00094
Liver:hepatoma	F	0/50	4/50	0.059
Liver:hepatoma	M	1/50	6/50	0.055
Lung:All tumors	F	13/50	20/50	0.1
Lung:Adenoma	F	6/50	12/50	0.096
Lung:Adenocarcinoma	F	7/50	11/50	0.22
Lung:All tumors	M	17/50	31/50	0.0045
Lung:Adenoma	M	12/50	24/50	0.006
Lung:Adenocarcinoma	M	9/50	13/50	0.23

From these results we can construct the following estimates for potency (q_1 and q_1^*) in mice.

Tumor site:type	Sex	q_1 (kg-d/mg)	q_1^* (kg-d/mg)
Bone:Various	F	1.1×10^{-6}	1.9×10^{-6}
Bone:Various	M	1.1×10^{-6}	1.9×10^{-6}
Forestomach:Various	F	3.0×10^{-6}	4.4×10^{-6}
Forestomach:Various	M	1.8×10^{-6}	2.9×10^{-6}
Lung:Total	F	1.3×10^{-6}	2.9×10^{-6}
Lung:Total	M	3.5×10^{-6}	5.8×10^{-6}

Using the EPA methodology, the value chosen from these would be the highest value of q_1^* that corresponds to a statistically significant result — 5.8×10^{-6} kg-d/mg — and this value would then have to be extrapolated to humans using a surface area factor of $(70 \text{ kg}/30 \text{ g})^{1/3} = 13.26$. Such an approach leads to an upper bound estimate of carcinogenic potency in humans of 7.7×10^{-5} kg-d/mg.

What does this imply for eating raw mushrooms in your salad?

(1) A upper bound estimate of potency of 7.7×10^{-5} kg-d/mg implies that the dose rate required to give an upper bound estimate of risk of 10^{-6} is 0.013 mg/kg-d, or about 23 g (0.82 oz) per lifetime.

(2) A consumption of 1 oz/month (13.3 mg/kg-d) of raw mushrooms corresponds to an upper bound estimate of lifetime risk of 1×10^{-3}.

(3) According to Toth and Erickson (1986), estimated annual US consumption of these mushrooms was 340×10^6 kg in 1984-1985. This was an annual average per capita consumption of about 55 mg/kg-d, corresponding to an upper bound estimate of lifetime risk of 4.3×10^{-3}. Presumably not all the mushrooms would be eaten raw, but we have no idea what would be the effect on the carcinogenicity of the mushrooms of cooking them.

(4) With the figures given in (3), the upper bound estimate of the annual number of cancers expected in the US to be due to mushrooms is about 8500!

Comment

Mushrooms are known to contain various compounds, including hydrazine analogs, that are mutagenic *in vitro* and/or carcinogenic in laboratory animals under certain conditions. An extract of mushrooms of the type tested has also been shown to be mutagenic. However, the spectrum of tumors found in this experiment on raw mushrooms was not what might be expected from the known carcinogenic compounds present in the mushrooms. Presumably there are different carcinogenic compounds are also present, or there was an interaction with other chemicals present.

References

Toth, B. and J. Erickson. 1986. Cancer Induction in mice by feeding of the uncooked cultivated mushroom of commerce *Agaricus Bisporus*. Cancer Research 46 (1986) 4007–4011.